THE

CROONIAN LECTURE

ON

MUSCULAR MOTION.

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From the PHILOSOPHICAL TRANSACTIONS.

THE CROONIAN LECTURE, &c.

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THE ſubject of muſcular motion has been ſo often conſidered, and in ſo many lights, that it is hardly poſſible to avoid many obſervations which are trite, and even puerile; which, when they occur, I beg the learned Society to forgive. They will alſo find ſo little new, or even nothing, that I ſhould be inexcuſable in taking up their time, if the ſubject was not annually to be diſcuſſed before them. In conſidering muſcular motion, I muſt begin with ſome obſervations on motion in general, and with that well known, and ſelf-evident axiom, that one particle of matter, conſidered by itſelf, will remain at reſt if it be at reſt, and will continue in motion if it be in motion, and in the ſame direction. This has been called the *vis inſita*, or *vis inertiæ*, of matter. It may be ſaid in other words, that a ſingle particle of matter being at reſt, would therefore always continue at reſt, if it were not for ſome external impulſe made on it. This impulſe may be from ſome other particle of matter in motion impinging upon it, and communicating part of its motion to it, while it communicates an equal quantity of its reſt to the matter ſo impinging upon it, ſo that the quantity of motion and reſt ſhall be the ſame after the impinging, in both bodies, as they were before: or, in other words, a ſimple particle of matter in motion would always

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continue in motion, in the ſame direction, if it did not meet with another, on which it impinged; and after the impinging, there would be the ſame quantity of motion and reſt in both bodies taken together, as was before. If we conſider equal motion, in direct contrary direction, as reſt; motion, or reſt, produced in a body by the above means, I ſhall call communicated.

If two ſimple particles of matter, of any ſpecies, not farther diſtant from one another than the ſun is from the earth, were both at perfect reſt, theſe two particles would inſtantly begin to move toward one another, if no other particle of matter whatever exiſted.

I do not mean to tire my learned Audience with demonſtration of propoſitions ſo well known.

There would, therefore, be an impulſe, producing motion between theſe bodies, without any contact.

Motions produced in this way, I call original motions.

The firſt conſideration with regard to any particular motion is, therefore, whether it be an original or communicated motion. If it be an original motion, it will follow the laws of that particular ſpecies of original motion; if it be a communicated motion, it will follow the laws of communicated motion.

Many obſervations ſhew, that muſcular motion is not a communicated motion, and therefore an original one.

In any ſyſtem of bodies, or particles of matter, affecting one another only by the motions already exiſting in them being communicated to one another, they may diminiſh their motion, or bring one another to reſt; but they never can increaſe the motion exiſting in the whole. It happens frequently, that the motions in the animal body are increaſed, without any alteration of external applications to it; the caſes are ſo numerous, that it is hardly worth bringing an example: we might

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mention the increaſe at times of the circulation, and all the motions of the fluids without the leaſt new motion in the ſurrounding bodies, or interference, or even knowledge of the mind. This motion muſt therefore be original, and not communicated.

In communicated motion, if one body be at reſt, and a motion be communicated to it by another, the power of the whole motion ſhall not be greater than that in the communicating body at the time of the communication. If I take out the heart of an animal, cut off the auricles, it will in many caſes continue to contract and dilate for ſome time. If it be left to come to reſt, and if ſoon after a needle be introduced into the ventricle, placed tranſverſely, and if the interior ſurface of the ventricle be pricked gently by the needle, the ventricle will contract with ſuch power as to force the needle deep into it: in this caſe, the force of the contraction of the ventricle is much greater than the power with which it was pricked by the needle; this contraction was therefore not communicated to it by the moving needle, but was generated, and therefore an original motion.

In all communicated motion, by which two bodies at a diſtance are brought near to one another, there muſt ſubſiſt ſome other matter, by which they may be drawn, or forced, nearer to one another; but in original motion, it is not at all neceſſary that any other matter ſhould exiſt at all. Two particles, placed at as great a diſtance from one another as the ſun is from the earth, as has been already obſerved, although at perfect reſt, would begin to move nearer one another, by the attraction of gravitation, if all other matter whatever were annihilated.

Moſt authors who have treated on muſcular motion have ſuppoſed, that it was a communicated motion; and that it was

produced by ſomething paſſing by the nerves, from the brain to the moving part. Three doctrines have been ſet forth; one, that there is a fluid paſſing along the nerves; a ſecond, that there is a vibration; and a third, that the nerves are ſurrounded with ſomething like electric matter, in which motion runs from the brain to the moving parts. Thoſe who have conſidered this ſubject muſt be tired of the arguments which have been brought to refute each of theſe; for no argument from fact has been employed to prove any one of them: I ſhall therefore leave them as mere chimeras of the brain. I have taken notice, that it is not requiſite for any motion to paſs between two bodies, exciting in each other an original motion, through or by any other matter: I have alſo ſhewn, that muſcular motion is an original motion: it follows, that it is not neceſſary for any motion, or communication, to paſs through any other matter, in order to bring the muſcular fibres into action.

One caſe of muſcular motion is, when a ſtimulus is applied to ſome part of the body, and a muſcle at a diſtance immediately contracts. It has been ſuppoſed in this caſe, that ſome influence was communicated to the nerve of the part where the ſtimulus was applied, and through it to the brain, and from the brain through the nerves of the contracting muſcle. Granting, for a little, that ſome motion may paſs along the nerves, and therefore that the end of the nerve, where the application was made, may be the part in which the original motion began, the ſtimulus frequently does not touch the end of the nerve; for if vapour of volatile alkali be applied to the noſtrils, an univerſal glow of heat, and increaſed circulation, will conſtantly take place; but the vapour of the volatile alkali could not touch the nerves of the noſtrils, the membrane being

being conſtantly covered with mucus, which the vapour could not penetrate without diſſolving it, which it had not time to do, and, if it had, would have united with it, ſo as to form a ſoap, void of any ſtimulating power.

If, therefore, the original motion began in the end of the nerves of the noſtril, it muſt be excited by a ſubſtance at a diſtance from the end of that nerve, without any communication of motion between the ſtimulus, that is, application producing the motion, and the end of the nerve in which it is excited; therefore, on any ſuppoſition, a ſtimulus is capable of exciting a motion, in a part at a diſtance, without any communication of motion; and it is therefore not neceſſary, that the nerves ſhould be at all employed in the motions of the body excited by a ſtimulus, as it can act at a diſtance without their intervening. Further, that the nerves are not employed in the motions excited by ſtimuli, is evident from this experiment: take the heart out of a living animal, cut all the nerves off as cloſe as poſſible, lay it in nearly the heat of the body of the animal, it will continue to contract for ſome time. As ſoon as it has ceaſed contracting, prick a fibre in one of the ventricles; both ventricles, and all their fibres, will contract inſtantly, although there be now no communication by the nerves, between many of the contracting fibres, and the fibre ſtimulated. It might be ſuſpected, that the motion of the fibre ſtimulated might affect the others: in this caſe the contractions would be progreſſive; but, on the contrary, the whole contract at once.

I cannot help bringing another inſtance, where ſtimuli produce action in parts at a diſtance, without any communication of motion by the nerves. When infuſion of cantharides is applied to the ſkin, as we ſay vulgarly, it is not applied immediately to the ſkin; but in the firſt inſtance to the mucous

and ſebaceous matter, which every where covers the ſcarf ſkin; under this lies the ſcarf ſkin, which the infuſion can hardly be conceived to come at; if it did, the ſcarf ſkin we know is perfectly impenetrable to ſuch a fluid; it can therefore never touch the ſkin, in which it excites inflammation, and on which it therefore acts at a diſtance, and excites motion, which no one can ſuſpect to come through the nerves: nor is there any motion through the mucus and ſcarf ſkin, of any other kind than would ariſe if an infuſion of any other inſect had been applied, which had no power of exciting inflammation.

From what has been ſaid we may conclude, that when a ſtimulus has been applied ſo as to excite motion in a diſtant part, no motion whatever takes place in the nerves, or is communicated by them from the part to which the ſtimulus is applied to the moving part.

I need not draw your attention to another propoſition, *viz.* that when a ſtimulus is applied to a diſtant part, ſo as to produce motion, it often happens, that the ſtimulating matter is not carried by the blood-veſſels, or otherwiſe, to the moving part. This propoſition has often been demonſtrated, and is well known.

All the original power exerted by any of the moving parts conſiſts in a power of particles coming nearer one another; for every muſcle or fibre becomes ſhorter when it acts; or, in other words, contracts; and every other moving part in like manner contracts when in action. It is true, that there are many contrivances to make the contraction have great effect in producing motion, force being never ſpared for conveniency, as my friend Mr. HUNTER has, I believe, already ſet forth to my learned audience: but, nevertheleſs, it is clear from every

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experiment made on the ſubject, that all motion ariſes from particles coming near one another in ſome direction. It would be ſuperfluous for me to point out theſe experiments; I ſhall mention one only, and an obvious one. Lay bare a muſcle, and prick any of its fibres, it immediately becomes ſhorter.

The original power of coming nearer to one another of two or more particles of matter, has been called attraction. There have been ſeveral original powers of coming nearer one another of particles of matter, which have been conſidered as different attractions, ſuch as the attraction of gravitation, of magnetiſm, of electricity, &c.; all of which this Society are too much maſters off, for me to enter into any diſquiſition with regard to them.

The attraction which is my preſent object, I call the attraction of life. This attraction is either of two ſpecies, or is exerted variouſly; for all the moving parts have their particles nearer one another in the living than in the dead body. The proof of this is as neceſſary as it is obvious. I muſt, therefore, take up a ſmall portion of your time in pointing it out. Take the body of any animal, when the life is entirely gone from it, and the effects of it are entirely loſt, but before any putrefaction, or any change in its chemical qualities, has taken place; and lay bare, and diſſect out, any muſcle, eſpecially one which has long fibres, and no middle tendon, ſuch as the *ſartorius*, for example, and afterwards lay it in its place, leaving it of the length it naturally takes; it will reach farther than from its origin to its inſertion; but lay bare, and diſſect out, the ſame muſcle in the living body, and it will always be ſhorter than from its origin to its inſertion. If it ſhould be ſaid, that the diſſection ſtimulated the muſcle, and brought it into action, let it not be diſſected out, but its tendon cut through, as the

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Tendo Achillis, for inſtance, the ſame thing will happen. And we now are all convinced, from various experiments, that a tendon in a ſound ſtate is not capable of being ſtimulated by being wounded, cut through, or broken.

I apprehend, then, that we may conclude, that all the moving parts are conſtantly contracted, that is, their particles are nearer one another when the body is alive, than when dead, and totally left to their elaſticity. This ſpecies of action I call the tone. The ſecond ſpecies, or variety, which occurs in the attraction of life, is when a moving part, for a ſhort time, has its particles brought nearer one another than they are from their tone, and which very rarely continues for many ſeconds of time without intermediate relaxation. I call it their action; when it does continue for a longer time, it is called ſpaſm; which, however, is ſo vague a term, that I could wiſh totally to reject it, at leaſt to confine it only to this ſenſe, *viz.* a greater contraction, or coming nearer one another of the particles, of a moving part, than that which would happen from their tone, remaining without any intermediate relaxation.

I for the preſent do not mean to ſay any thing farther with regard to the tone, or ſpaſm of parts; but only to call to your conſideration the action, as excited by applications to ſome part of the body at a diſtance from the moving part. I have already rejected all communication by the application, or ſtimulus, being carried by the blood-veſſels, or any other way whatever, to the part. I have alſo rejected any motion, or communication of any kind whatever by the brain and nerves to the part. I conceive, that when any ſtimulus or application whatever is made in any part, ſo as to produce any action in a diſtant part, that that medicine or application, without having any operation whatever on the intermediate parts, gives a

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power to the particles of the moving part of greater attraction. I ſhall illuſtrate this idea by ſuppoſing, that there is a machine moving by various powers, either original or communicated; and that in this machine there are two magnets, which by their attractive power have come to a given diſtance from one another, but have been prevented from coming nearer by ſome power endeavouring to draw them back. A much ſtronger magnet applied to a part of the machine, in a certain manner, ſo as not to touch either of the two already there, nor to affect any other part, may increaſe their power of attraction, ſo as to make them overcome the reſiſtance, and come nearer one another *.

In the ſame manner, I apprehend, that an application made to the ſkin of the abdomen may, and often does, occaſion the action of the inteſtines to take place, without any effect whatever on the intermediate parts; but that it ſimply excites the attraction of the particles of the moving parts of the inteſtines; certainly a part of the matter through which the influence is to paſs, *viz*, the mucus and ſcarf ſkin, is actually inanimate matter.

In certain caſes of original motion, there is attraction, or the coming nearer of particles only. In others, there is not only attraction, but oppoſite repulſion; the caſes of which are unneceſſary to enumerate to this Society. In the attraction of life there is no oppoſite repulſion; all the motions of the body are produced entirely by the force of particles coming nearer one another. When this force diminiſhes, or the action goes off, and leaves the part entirely to its tone, the particles of the moving part are by no means repulſed from one another, but

* I do not mean to inſinuate, in the ſmalleſt degree, that the powers of the body at all depend on, or have any thing to do with, magnetiſm.

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are left to be drawn aſunder by their elaſticity, weight, or the weight of the ſurrounding parts, or any other accidental power: but, nevertheleſs, there are applications which may be made to diſtant parts of the body, which may, and do, take off the attraction which occaſions the action of the moving part; and all thoſe reaſonings which I have already applied to applications which excite action, and which are called ſtimuli, are equally applicable to thoſe applications which make action ceaſe, and which we call ſedatives.

The great ground on which I have attempted to make theſe obſervations, is the foundation of certain maxims in the practice of medecine, which I ſhall now proceed to ſketch out to the Society, whoſe inſtitution, to me, has always ſeemed to include the philoſophy, but not the actual practice, of medicine.

Medicine is a ſcience of long cultivation in that channel in which all the ſciences have flowed, and had early attained great perfection, I believe, from the teſtimony of various writers of antiquity, and other circumſtances, which I paſs over as well known to many of this learned body, and too foreign a digreſſion from our preſent ſubject: for although CELSUS obſerves well, that there could be no phyſicians among the Greeks at the time of the Trojan war, inaſmuch as HOMER never mentions one medicine, but only application to the Gods for the cure of fevers, and other internal diſeaſes; yet the Egyptians, from whom the Greeks received a great part of their knowledge in all ſcience, as well as in medicine, had certainly not only regular phyſicians for internal diſeaſes, but likewiſe ſtone-cutters, oculiſts, auriſts, &c. long before the Trojan war; and HIPPOCRATES, by his own teſtimony, took much of his knowledge from what he calls the ancients. In the progreſs, therefore, of the

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ſcience of medicine, it came into my mind to enquire how far, and on what ground, the modern increaſe of ſcience in anatomy, chemiſtry, mathematics, &c. had forwarded the knowledge of medicine. In the firſt place, it is well known to my learned Audience, that medicine was in the hands of Greek phyſicians from the time of HIPPOCRATES, or rather from the deſtruction of the Egyptian monarchy by CAMBYSES, down to the time of the Cruſades; in all this time there was hardly a diſſection of the human body, from an opinion about *manes*; but when it came into Europe again, where this opinion remained indeed, but in a much leſs degree, anatomy began again to flouriſh; and by other means all the other ſciences ſhone forth with a greater luſtre than they had ever done in any period handed down to us by hiſtory of any nation. It was obvious therefore to conceive, that the knowledge of the ſtructure of the body, and the inveſtigation of the powers of matter, made in a more accurate manner, and on a more extenſive ſcale, would elucidate the doctrine of the human body, and its diſeaſes, and their treatment, in a new and more perfect manner: to this opinion I mean now to apply the reaſoning I have before laid down.

In the ſtructure and phyſiology of the body, two great diſcoveries have been made by the moderns; the circulation of the blood; and the lymphatics, and abſorption of the lymph. Theſe at once overthrow the ideas of the ancients with regard to moſt of the functions of the interior parts of the body; which was now conceived by many to be an hydraulic machine, and ſubject to all thoſe diſorders which were incidental to ſuch a machine; and particularly, from various fluids flowing with great rapidity, through tubes, many of them of infinite fineneſs, that ſtoppages muſt often take place, which

were to be removed by diſſolving out the obſtructing matter; that the blood was mixed ſo perfectly through all the body, and ſo conſtantly, that the ſame blood muſt be taken away, whatever blood-veſſel was opened; and when we contemplate the numerous openings and communications of the veſſels with one another, that blood flowing out of any one will empty them all equally, and that, therefore, it can be of no conſequence from what part of the body blood is evacuated. In a pleuriſy, for inſtance, where can be the difference, whether blood be taken from the right or left arm, or from the veſſels of the ſkin of the breaſt? But there is a difference, and a great one too; ſince taking a much leſs quantity of blood from the ſkin of the breaſt, is actually known, in certain caſes, from experience, to cure a pleuriſy, than would have had that effect if taken from the veſſels in the arm, and will even carry off the diſeaſe, when it could not be carried off at all by evacuation from the arm: yet it is undoubtedly the very ſame blood in all its qualities; and in both caſes the veſſels of the pleura are equally emptied. The act of flowing out of the blood from the veſſels of the ſkin of the breaſt then has an immediate action on the action of the moving parts in the pleura, and carries off the inflammation independent of the circulation, or any of its laws; and ſo far has the knowledge of the circulation been of any advantage in this caſe, that it had nearly thrown out topical bleeding in inflammation, which is one of our moſt powerful remedies in the diſeaſe. In like manner, when the moving fibres of the ſtomach do not contract, ſo as to expel any vapour that may get into it, a ſpice applied to the ſkin over the ſtomach will, in many caſes, occaſion theſe fibres to contract. Now it is well known from anatomy, that there is no communication between the ſkin of the abdomen

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and the ſtomach; and if the ſpice were to act by touching theſe fibres, it would be the ſame, whether it was applied to the ſkin over the ſtomach, or to the ſkin of the arm; for in both caſes it muſt be abſorbed by the lymphatics, and carried to the left ſide of the heart, and there and in the lungs be blended univerſally with the whole blood, and carried by the arteries to the moving fibres of the ſtomach. Nay more, that it would be equal, whether it was applied to the inner ſurface of the ſtomach itſelf, or to the external ſkin, or any other membrane, of any other cavity: for the ſtomach is covered with mucus, and lined with a membrane which is perfectly impervious, and totally prevents any thing contained in the ſtomach from being any way applied to the moving fibres; it muſt in this caſe, therefore, be likewiſe taken up by the lymphatics, or lacteals, and carried to the heart before it could touch the moving fibres of the ſtomach. The maxim then, ariſing from our knowledge of the lymphatics, would be, that it was of no conſequence where we applied a ſpice in caſes of flatulency; which is not true. By ſimilar reaſons it might be eaſily ſhewn, were it not for tiring my learned Audience, that all the knowledge of the properties of the fluids, which has been acquired by modern and accurate experiments, hardly contributes any thing to the knowledge of applying medicines for the cure of diſeaſes; and that the ſtudy of the laws of the attraction of life, or what has been called muſcular motion, is of conſiderable importance.

One more obſervation I have only to make, *viz.* that all original motions are by their nature perfectly unintelligible as to their cauſe; who can tell the cauſe of gravity, chemical attraction, &c.? and ſo undoubtedly the attraction of life, in its cauſe can never be inveſtigated, being, like all other attrac-

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tion, a power which two or more particles of matter have of coming nearer one another. But although the study of causes of original powers be totally absurd and futile, yet the laws of their action are capable of investigation by experiment, and applicable to the evolving much useful knowledge. Need I remind this Society, that the investigation of the laws of gravitation, by Sir ISAAC NEWTON, has rendered it immortal? The investigation of the laws of the attraction of life has also been greatly forwarded by one of its present members; but it is an investigation which will probably require ages to render perfect.